INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US00/16835

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, pages:

6-14	as originally filed			
1-5	as received on	27/06/2001	with letter of	22/06/2001

Claims, No.:

1-25	as received on	27/06/2001	with letter of	22/06/2001

Drawings, sheets:

1/3-3/3	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-25
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-25
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-25
	No:	Claims	

2. Citations and explanations
   see separate sheet

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

The document **D1** [*GB-A-1 263 916 (WADDLETON N) 16 February 1972*] describes an apparatus for inhibiting the growth of microorganisms in water comprising a passageway, at least two injections devices located at spaced dosing locations, a source of a substance inhibiting the growth of microorganisms connected to the passageway and an adjustable flow control device to regulate the flow of the substance to be injected (cf. claim 1 and page 2, lines 77-103).

D2 [*US-A-4 690 764 (OKUMURA MUNEHIRO ET AL) 1 September 1987*] shows (cf. Fig. 8 and 9) an apparatus useful for the dissolution of a disinfectant in sterilization processes (col. 7, l. 21-22) comprising at least two injection devices located at spaced dosing locations.

Present apparatus and method are novel because the prior art fails to teach an adjustable flow control device which is configured to provide a lesser flow of disinfectant through each injection device than the flow through an injection device located upstream therefrom.

The apparatus and method of the invention appear to employ a lesser total quantity of disinfectant than is required with the traditional dosage techniques, thus providing an effective treatment process while reducing the residual disinfectant level at the end of the treatment.

The idea of providing a lesser flow of disinfectant through each injection device than the flow through an injection device located upstream therefrom is not suggested by the prior art.

Therefore, the claims appear to meet the requirements of Art. 33 PCT.

SEQUENTIAL DISINFECTANT TREATMENT FOR WASTE WATER

The present invention relates generally to a method and apparatus for treating waste water and, more specifically, to a method and apparatus for treating wastewater to reduce bacterial contamination thereof through sequential dosing of a stream or column of waste water with a single disinfectant agent such as chlorine.

Pollution attributable to the discharge of waste water into bodies of water such as rivers, lakes, estuaries and larger bodies of water has long been recognized as a significant public health problem due to the presence therein of bacterial and viral microorganisms posing threats to humans and other animal life. Untreated waste water typically carries fecal material, which includes coliform bacteria, posing a significant health risk. Chlorination is a well known method of treating waste water to reduce the levels of bacterial and viral microorganisms to recognized, acceptably low levels. Dissolution of chlorine in water forms a mixture of hypochlorous ($HClO$) and hydrochloric (HCl) acids. The latter completely dissociates into hydrogen and chlorine ions, while the former only partially dissociates into hydrogen and hypochlorite ions, relating to the pH of the water. In either case, the chlorine effectively destroys and suppresses the bacterial and viral microorganisms present in the wastewater.

Chlorine also, unfortunately, reacts with other substances typically contained in waste water to form, over time, other compounds. For example, chlorine reacts with ammonia to form chloramines. Thus, overtime, chlorine is depleted from the waste water or, stated another way, chlorine demand is time-dependent. The amount of active chlorine present in waste water at any given time is referred to in the art as the "free chlorine residual", or merely the "residual". Residual may be determined as the difference between the demand to the time of determination and the total chlorine dosage introduced into the waste water.

In stage one sewage treatment plants, a common method of disinfecting waste water is by injecting gaseous and/or liquid chlorine into that water as it enters a "contact tank". In such a disinfection process, it is important to provide a sufficient dose of chlorine to "contact" a body of flowing waste water effluent for a sufficient period of "contact time"

to effect disinfection of the water to an acceptably low level of contamination. The dosage and contact time must be sufficient to achieve the desired level of disinfection without a large excess of residual chlorine in the treated water. For example, a typical public health standard may require disinfection of the waste water so that there are no more than 5000 coliform colonies per milliliter ("cfu/ml") in the treated water with a residual chlorine level of about 0.1 part per million (ppm).

A typical design for a "contact tank" is shown in Figures 1 and 2. In such a contact tank, the waste water is disinfected by providing an initial, single dose of chlorine to the water as it enters the contact tank. As shown in Figure 2, the chlorine is typically injected throughout, or across the cross-sectional area of, a moving waste water column entering the contact tank at a single dosing location. This dose of chlorine is carried with the water in plug flow fashion and disinfects that water as it passes through the tank. A typical problem with such a single dosage disinfection process is that chlorine has a short half-life in water. Thus, the initial dosage of chlorine must be carefully selected to be of sufficient magnitude to ensure that the free chlorine residual will be sufficient during the time of passage through the contact tank to disinfect the water to a desired low level of contaminants without an unacceptable residual chlorine level remaining at the end of the treatment process.

One such system employing single point dosage chlorination process in U.S. Patent 4,019,983 (to Mandt) issued April 26, 1977. Mandt discloses a method for disinfecting waste liquid such as sewage effluent by means of a single dosage of a disinfecting agent. Mandt is particularly drawn to a method wherein the disinfecting agent and waste liquid pass through a turbulent flow zone for mixing purposes.

A significant problem with the traditional, single point dosage chlorination process is attributable to application of chlorine only at the entrance to the contact tank, as it is very difficult to accurately judge the proper, single chlorine dose to be added to the waste water. The proper dosage must be adjusted according to the bacterial loading and inherent organic chlorine demand of the waste water, as well as the amount of effluent in that waste water. An additional problem is due to the extended residence time of each portion of the flow of waste water in the contact tank, typically about 30 minutes for a

tank about 70 meters long. Because chlorine is injected into the waste water at a single point, the aforementioned "plug flow" results. As each "plug" or segment of waste water flows through the contact tank, the chlorine reacts with the inherent organic material and bacteria in the surrounding waste water and with any effluent in that waste water. Those reactions reduce the free chlorine residual available for treatment of the harmful microorganisms and may, in some circumstances, reduce the free chlorine residual to a level insufficient for effective treatment. Thus, the proper single chlorine dosage at the contact tank entrance must be varied to accommodate flow rate, the length of the flow path through the contact tank, bacterial and viral contaminant loading (bacterial loading usually being used as the standard), the concentration of effluent in the waste water, and the inherent chlorine demand attributable to organics in the waste water. Failure to regulate the chlorine dosage properly may result in either an unacceptably high level of microorganism colonies at the end of the treatment process or an unacceptably high residual chlorine level. As the former result is more undesirable, the conventional approach is to introduce an excessive chlorine dose, resulting in excessive residual chlorine but at least complying with the requisite public health standards. However, such an approach requires a relatively larger chlorine generation capacity, with attendantly larger capital and operating expenses.

Finally, as previously noted, chlorine exhibits a short half-life. Thus, using the plug flow of waste water to "carry" a single chlorine dose along full length of the flow path through the contact tank for the extended tank residence time is inefficient due to the resulting deterioration of the chlorine concentration.

The problems associated with single dosage processes are further compounded by variations in the composition of the waste water. This can be particularly true in Hong Kong and other locales where the entire sewage system utilizes sea water or another water source exhibiting highly variable bacterial loading and organic content. Because sea water has exceptional seasonal variation in composition, including its inherent organic content and bacterial loading, the continuous attainment of both the desired bacterial count standard and the residual chlorine level standard in the treated water is very difficult. An inability to meet both standards is unacceptable where a water permit

or other environmental regulation sets specific limits for both bacterial counts and residual chlorine levels.

As noted above, the typical treatment process applies a high dosage of chlorine at the single initial injection site to ensure adequate disinfection for the entire waste water flow path. However, the resulting chlorine residual in the treated water is unacceptably high from an environmental standpoint due to harm to fish and other forms of marine life, which impairs commercial harvest yields of marine life and may also have an adverse affect on fishing-dependent tourism.

Technologies other than chlorine dosage, such as ultraviolet and ozone treatments, have been developed to disinfect waste water. These alternatives are unacceptable in many locations, however, due to higher capital and operating expenses than those associated with the above-described conventional chlorination technique. Such technologies may also present safety and environmental problems not associated with the conventional chlorination technique.

An example of an alternative system includes U.S. Patent 4,690,764 (to Okumura et al.) issued Sept. 1, 1987. The Okumura patent discloses an aerator including a jet steam generator for injecting a gas, such as oxygen or ozone, and a liquid in a mixed state from a nozzle to treat waste water. The Okumura patent further discloses utilizing multiple aeration nozzles at spaced locations in a tank but fails to teach the applicability of such a system to chlorination techniques. Further, the Okumura fails to teach a reduction of overall disinfectant relative to a single dosage system.

Additional systems employing multiple nozzles in a system include British Patent 1,263,916 (to Waddleton) issued Feb. 16, 1972 and PCT Application Publication No. WO 98/51404 (for Life Technologies, Inc.) published Nov. 19, 1998.

The Waddleton patent discloses a method and apparatus for inhibiting the growth of slime in paper machines including injection of a slime inhibiting substance at multiple dosing points within the machine. However, Waddleton is concerned with continual treatment of recycled fluids within the paper mill machine fails to indicate that such a system is applicable to waste water treatment.

The Life Technologies application, while disclosing a fluid system having multiple

nozzles at spaced locations, deals with the continuous preparation of cell culture medium formulations and buffered salt solutions from selected groups of medium concentrates. The multiple nozzles allow introduction of different medium concentrates for mixture without adverse chemical reaction. However, the Life Technologies application fails to disclose the use of multiple nozzles for use in waste water treatment. Further, the Life Technologies application fails to teach the use of multiple nozzles to deliver multiple doses of the same medium at spaced locations.

BRIEF SUMMARY OF THE INVENTION

The present invention includes a method and apparatus for sequentially dosing waste water flowing along a path, such as in a contact tank, at multiple locations along the length of the flow path. The invention affords the advantages of administering doses of disinfectant at spaced points along the flow path such that an effective level of disinfectant is maintained throughout the length of the flow path to achieve the desired reduction in bacterial and viral microorganisms while emplying a lesser total quantity of disinfectant than is required with a traditional single-dosage technique, thus providing an effective treatment process while reducing the residual chlorine level at the end of treatment.

CLAIMS

I claim:

1. An apparatus for disinfection of waste water comprising an elongated passageway (15), at least two injection devices respectively located at spaced dosing locations (1, 2, 3, 4) along the passageway (15) for introduction of a disinfectant to a stream of waste water flowing through the passageway (15), a source of disinfectant (30), a conduit arrangement (35) extending between the disinfectant source (30) and each of the dosing locations (1, 2, 3, 4), and an adjustable flow control device (60) positioned to regulate flow of disinfectant to each of the at least two injection devices through the conduit arrangement (35) characterized in that the adjustable flow control devices (60) are, in combination, configured to provide a lesser regulated flow of disinfectant through each respective injection device than a regulated flow of disinfectant through an injection device located upstream therefrom.

2. The apparatus of claim 1, wherein said source of disinfectant (30) comprises, at least in part, a source of chlorine (30).

3. The apparatus of claim 1, wherein said passageway (15) is defined within a contact tank (10).

4. The apparatus of claim 1, further comprising a controller (65) operably coupled to each of the flow control devices (60) to initiate adjustment of a regulated flow of disinfectant to each of the at least two injection devices.

5. The apparatus of claim 4, further comprising at least one sensor device (70) positioned in the passageway (15) and configured to sense at least one parameter usable for determining a desirable flow of disinfectant into the waste water, the at least one sensor device (70) being operably coupled to the controller (65), the controller being programmed to initiate adjustment of at least one of the flow control devices (60) to vary a flow of disinfectant therethrough responsive at least in part to an output signal from the

at least one sensor device (70).

6. The apparatus of claim 4, wherein the controller (65) is configured to initiate adjustment of at least one of the flow control devices (60) to vary a flow of disinfectant therethrough responsive at least in part to a flow rate of the waste water stream and a disinfectant demand of the waste water stream proximate at least one dosing location (1, 2, 3, 4).

7. The apparatus of claim 1, wherein the plurality of injection devices is in excess of two injection devices.

8. The apparatus of claim 7, wherein the dosing locations (1, 2, 3, 4) are spaced at substantially equal intervals.

9. The apparatus of claim 1, wherein each of the injection devices comprises a group of injectors (40) fed by a single conduit of the conduit arrangement (35).

10. The apparatus of claim 1, further including a source of dosing liquid (45) in communication with the source of disinfectant (30).

11. The apparatus of claim 1, further comprising at least one pretreatment (90) unit upstream of the passageway (15), the at least one pretreatment unit (90) being operable to treat the waste water stream to enhance the effectiveness of the disinfectant.

12. The apparatus of claim 1, further including at least one post-treatment unit (100) positioned downstream of the passageway (15), the at least one post-treatment unit (100) being operable to further treat the wastewater discharged from the passageway.

13. A method of disinfection of waste water comprising flowing waste water along an elongated flow path (15) and introducing a disinfectant into the waste water at a plurality

of space dosing locations (1, 2, 3, 4) along the elongated flow path characterized by controlling a dosage of disinfectant to each of the plurality of dosing locations (1, 2, 3, 4) wherein each dosage of disinfectant is less than a dosage of disinfectant introduced into the waste water at a dosing location upstream thereof.

14. The method of claim 13, wherein introducing a disinfectant comprises, at least in part, introducing chlorine.

15. The method of claim 13, wherein said flow path (15) is defined within a contact tank.

16. The method of claim 13, further including selecting proportional dosages of disinfectant among the plurality of dosing locations such that an effective level of disinfectant is maintained along the flow path (15) employing a total amount of disinfectant less than an amount of disinfectant required for dosing at a single location to maintain the effective level.

17. The method of claim 16, wherein selecting is based at least in part on a flow rate of the waste water and a disinfectant demand of the waste water proximate at least one dosing location (1, 2, 3, 4).

18. The method of claim 16, further including providing a plurality of dosing locations (1, 2, 3, 4) in excess of two dosing locations.

19. The method of claim 18, further including spacing the dosing locations (1, 2, 3, 4) at substantially equal intervals along the elongated flow path (15).

20. The method of claim 13, further including providing a source of disinfectant (30) and directing the disinfectant from the source to each of the plurality of dosing locations (1, 2, 3, 4).

21. The method of claim 20, further including varying the dosage of disinfectant introduced into the waste water at at least one of the plurality of dosing locations (1, 2, 3, 4) at least in part responsive to at least one parameter sensed in the waste water.

22. The method of claim 20, further including providing a source of dosing liquid (45), mixing the disinfectant with the dosing liquid and carrying the disinfectant to the dosing locations (1, 2, 3, 4) using the dosing liquid.

23. The method of claim 22, further including providing the dosing liquid by diverting a portion of the waste water.

24. The method of claim 13, further comprising pretreating the waste water upstream of the first dosing location.

25. The method of claim 13, further comprising post-treating the waste water downstream from the last dosing location.